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(54) **COMPLEX CIRCUIT BOARD FABRICATION METHOD**

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(30) **Foreign Application Priority Data**

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**H05K 13/00** (2006.01)

**H05K 1/14** (2006.01)

**H05K 3/22** (2006.01)

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**H05K 1/02** (2006.01)

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(2013.01); **H05K 3/22** (2013.01);

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USPC ..... 29/832, 846, 852  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

5,297,968 A 3/1994 Johnson et al.  
5,358,412 A 10/1994 Maurinus et al.

(Continued)

**FOREIGN PATENT DOCUMENTS**

CN 200962689 Y 10/2007  
DE 3223832 A \* 12/1983

(Continued)

**OTHER PUBLICATIONS**

English translation of abstract of CN 200962689 Y (published Oct. 17, 2007).

China Office Action dated Nov. 1, 2011.

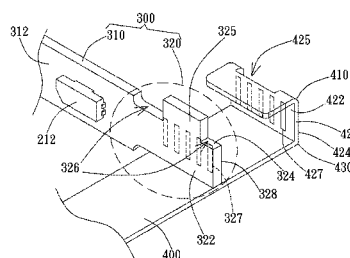
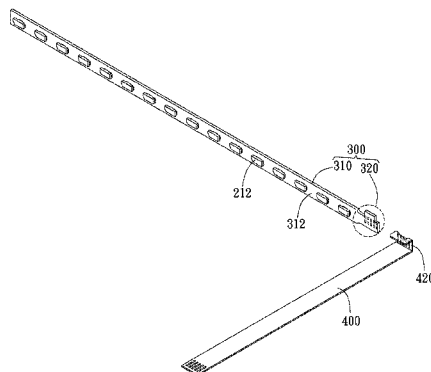
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(57) **ABSTRACT**

A complex circuit board including a printed circuit board assembly (PCBA) and a flexible printed circuit (FPC) for providing driving signals for light sources is disclosed. The PCBA includes a supporting portion and a connecting portion. The light sources are disposed above the supporting portion. The connection portion contacts electrically with a contacting portion of the FPC. The contacting portion of the FPC has a fixing hole. The connecting portion of the PCBA has a fixing portion. Moreover, the FPC has two or more than two first bend portions on the contacting portion. The fixing portion of the PCBA is inserted into the fixing hole of the FPC to complete the complex circuit board without extra attachment units. Therefore, the assembly procedure is simplified to increase throughput and the cost is reduced.

**8 Claims, 9 Drawing Sheets**



(52) **U.S. Cl.**

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(2013.01); *Y10T 29/4913* (2015.01); *Y10T*  
*29/49126* (2015.01); *Y10T 29/49144* (2015.01)

6,452,754	B1	9/2002	Mizuta et al.
7,887,210	B2	2/2011	Kim
8,172,417	B2	5/2012	Baar
8,212,961	B2	7/2012	Kim
8,264,654	B2	9/2012	Lee
2005/0259387	A1	11/2005	Sung et al.

(56)

**References Cited**

FOREIGN PATENT DOCUMENTS

U.S. PATENT DOCUMENTS

DE	3223857	A	*	12/1983
TW	200539781			12/2005

5,920,465	A	7/1999	Tanaka
6,342,932	B1	1/2002	Terao et al.

\* cited by examiner

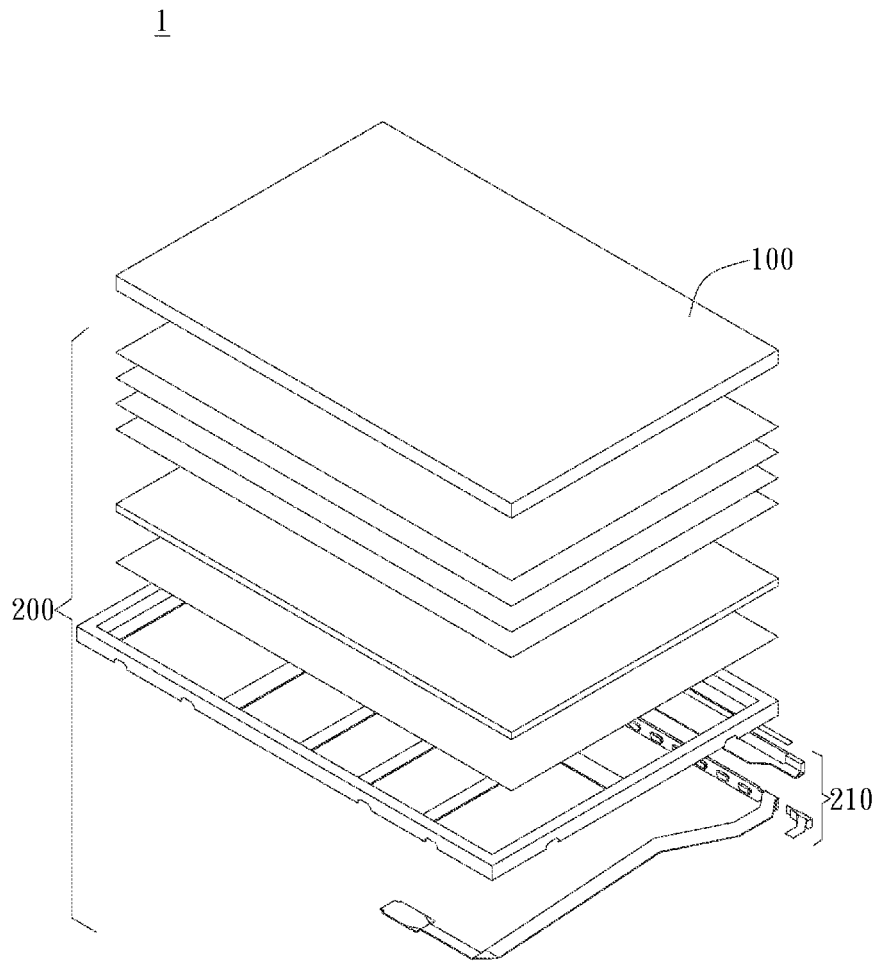
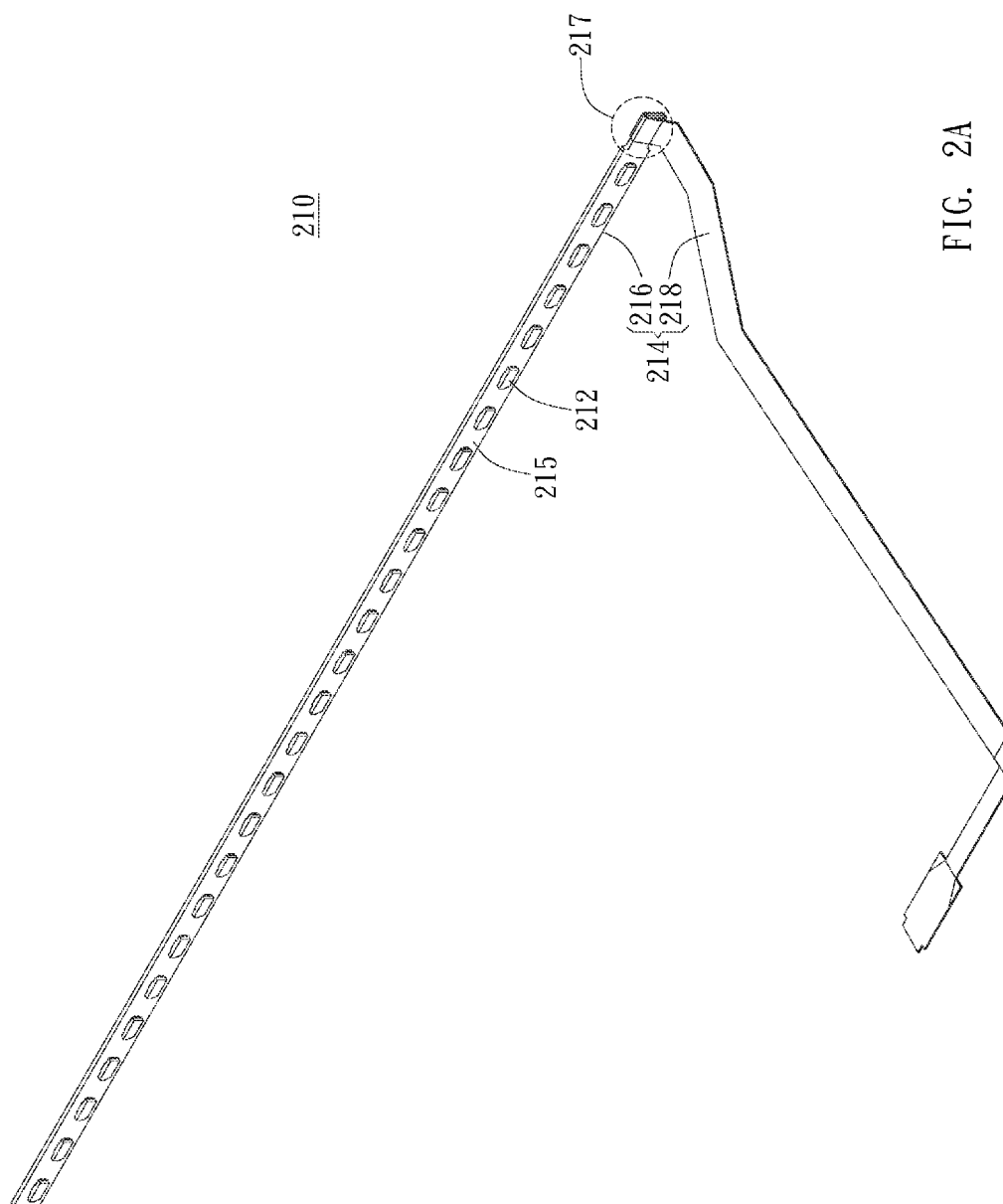


FIG. 1



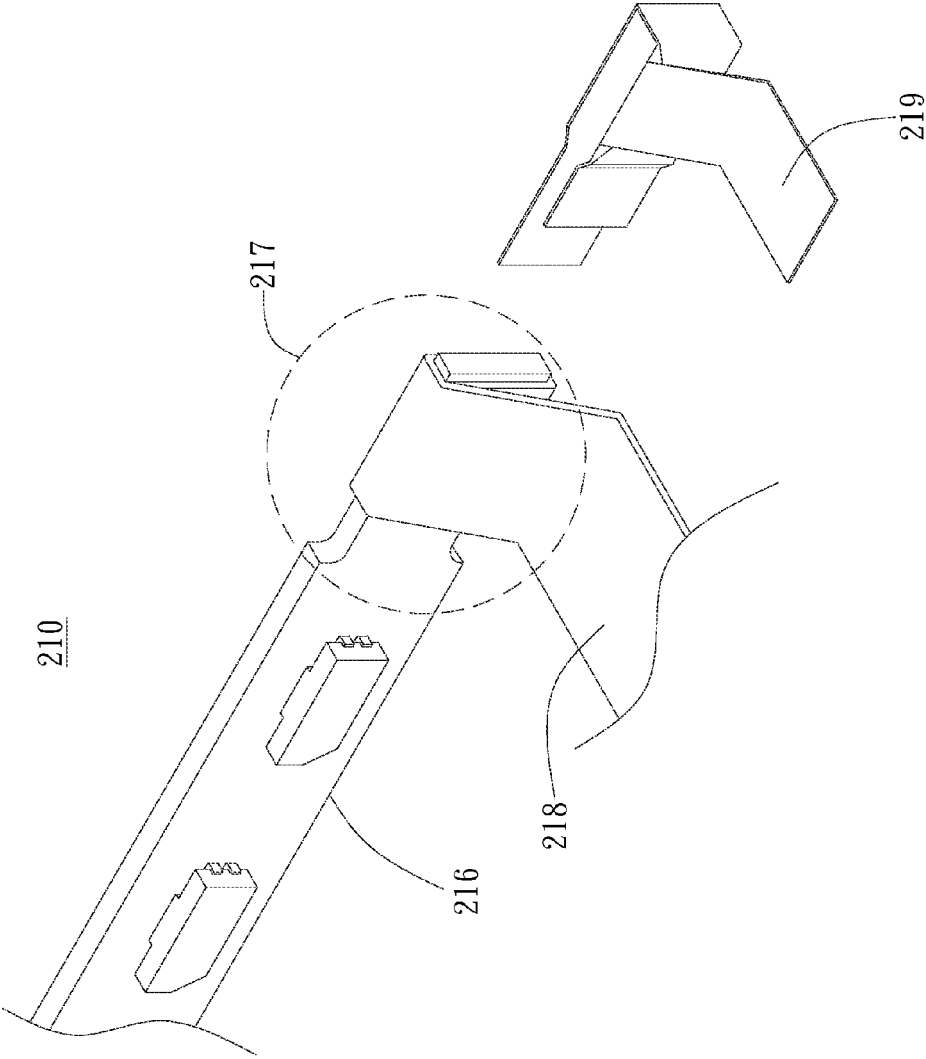


FIG. 2B

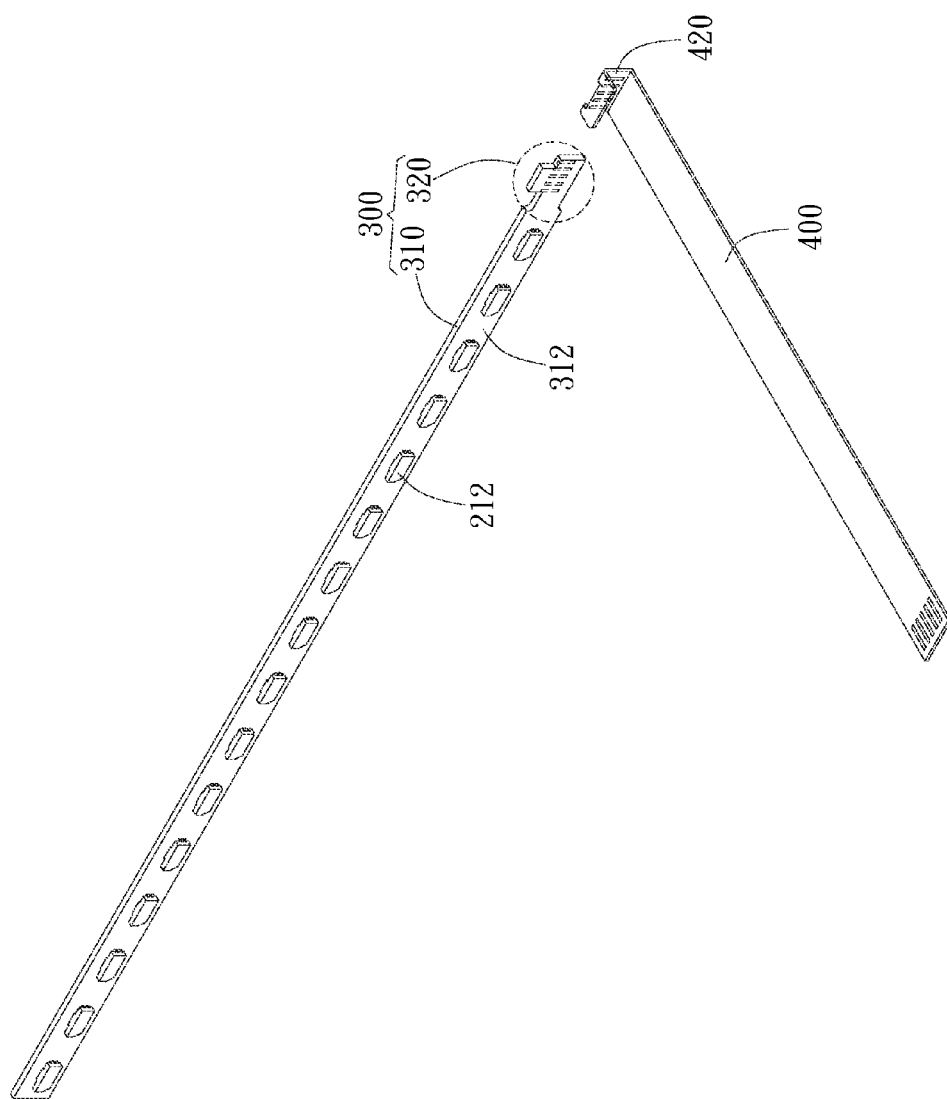


FIG. 3A

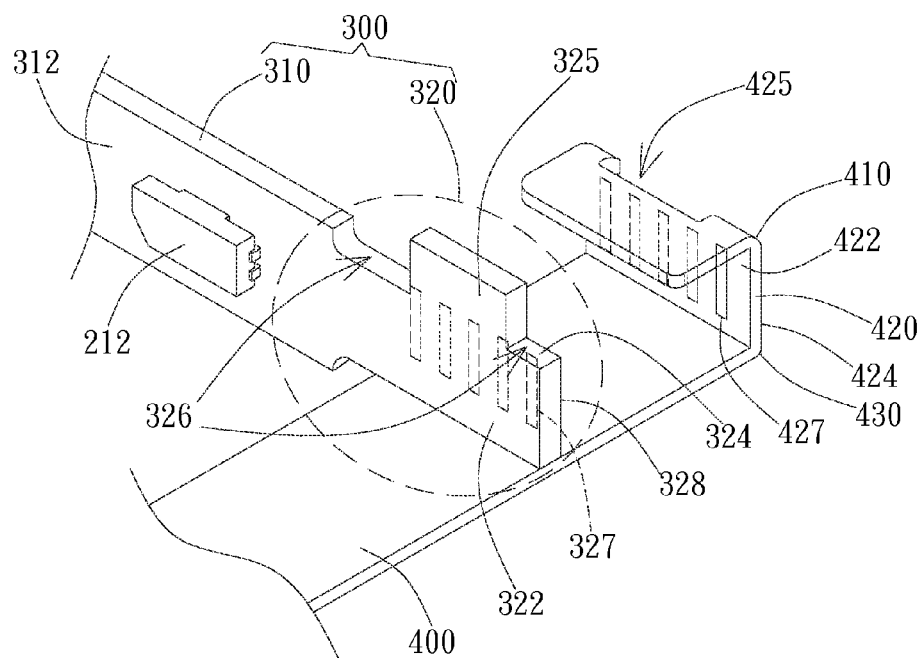


FIG. 3B

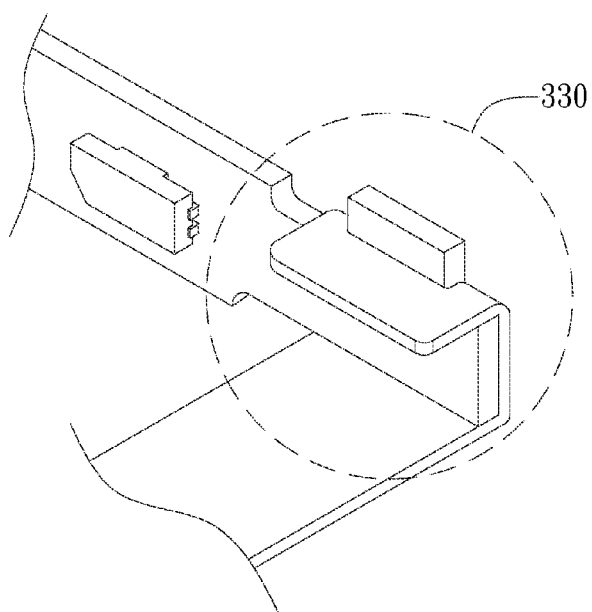


FIG. 3C

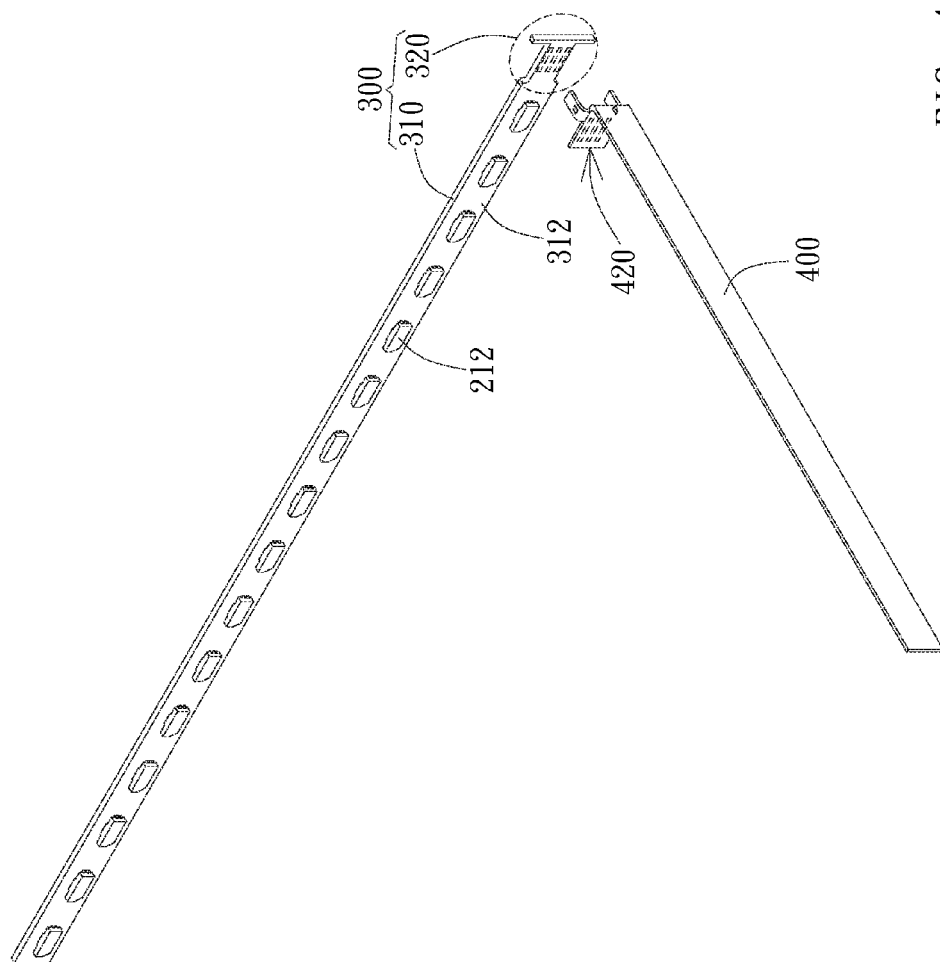


FIG. 4A



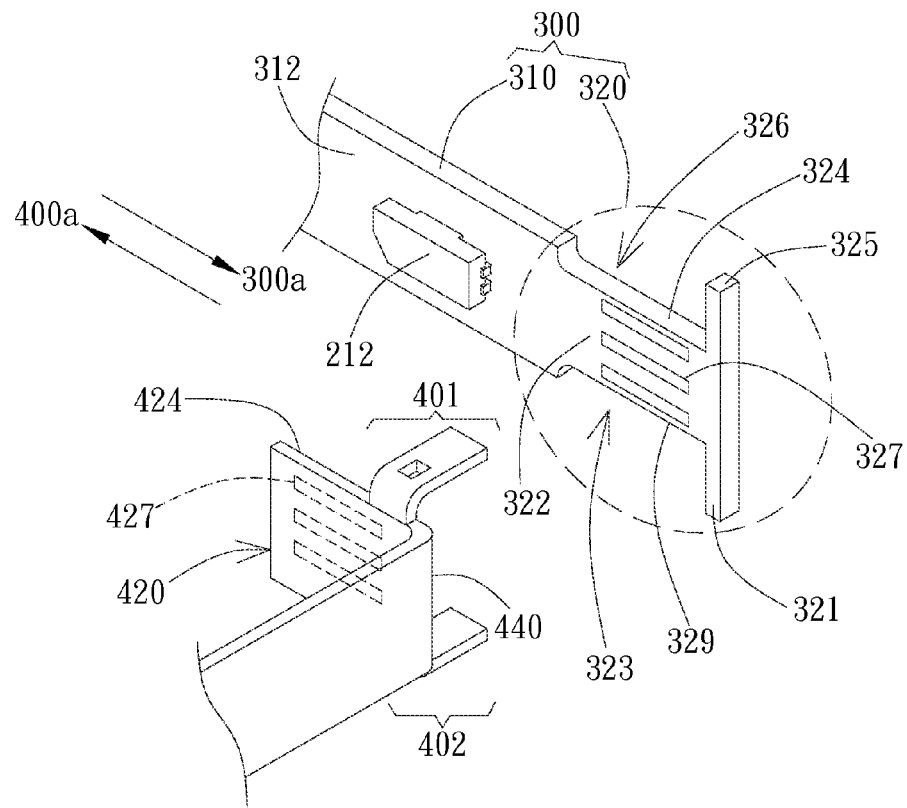


FIG. 4B

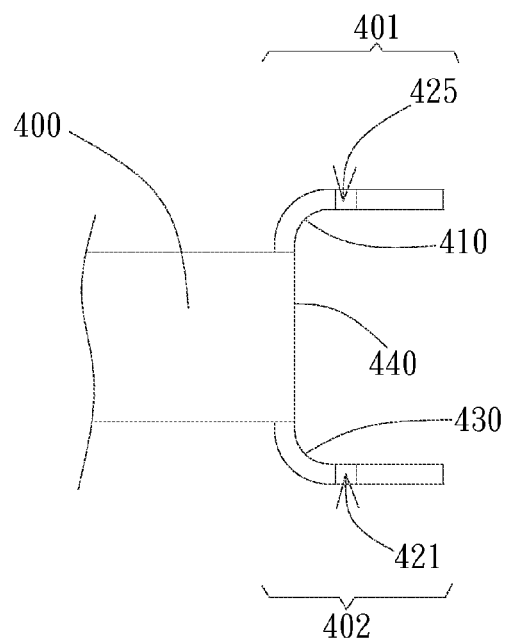


FIG. 4C

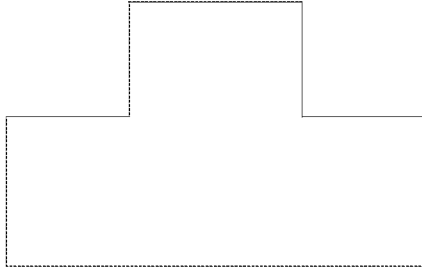


FIG. 5A

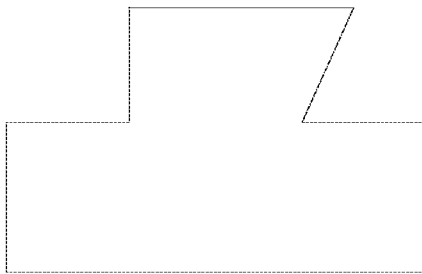


FIG. 5B

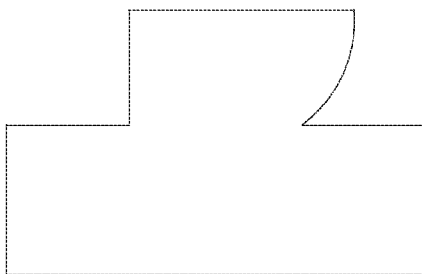


FIG. 5C

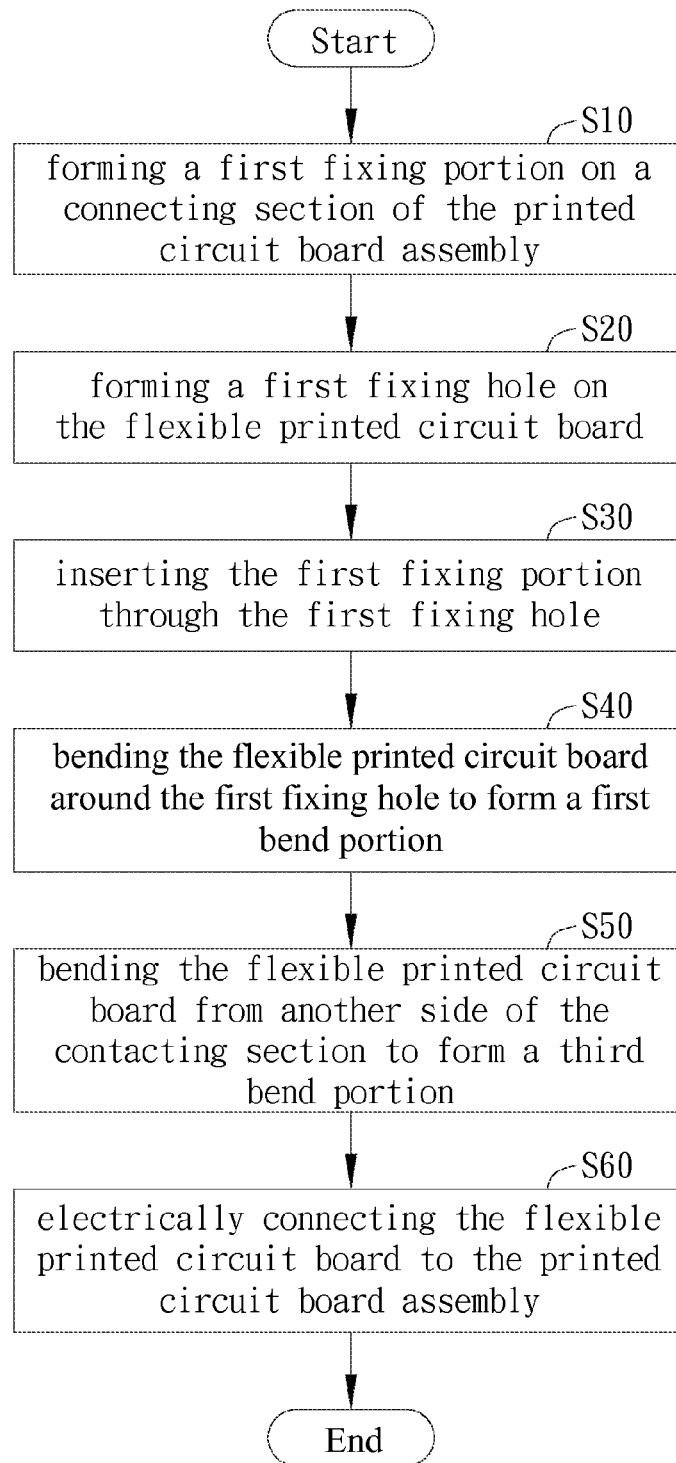


FIG. 6

1

## COMPLEX CIRCUIT BOARD FABRICATION METHOD

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention generally relates to a complex circuit board and a fabrication method thereof, particularly to a technology of combining circuit boards using corresponding fixing structures thereof to form the complex circuit board without extra attachment units.

#### 2. Description of the Prior Art

Various display electronic products have been developed in recent years. Among various types of flat displays, liquid crystal displays (LCD) have become the mainstream products, for example, LCD TVs and computer LCD monitors.

FIG. 1 is a schematic view of a conventional liquid crystal apparatus. A display apparatus **1** has a display panel **100** and a backlight module **200**. The backlight module **200** has a light-emitting device **210**. The light-emitting device **210** supplies backlight for the display panel **100**. Therefore the display apparatus **1** displays full color image for viewers.

FIG. 2A is a schematic view of the light-emitting device **210**. The light-emitting device **210** has light sources **212** and circuit boards **214**. The circuit boards **214** transmit signals to the light sources **212** to control the power or the brightness of light sources **212**. Light emitting diodes (LEDs) could be used as the light sources **212**. The circuit boards **214** include a printed circuit board assembly (PCBA) **216** and a flexible printed circuit (FPC) **218** combined with each other. The printed circuit board assembly **216** has a supporting surface **215** and the light sources **212** are disposed on the supporting surface **215**. The printed circuit board assembly **216** has a combining section **217** for attaching a bend portion of the flexible printed circuit **218** onto the printed circuit board assembly **216** and electrically transmitting driving signals of light sources.

FIG. 2B illustrates a combining method for the circuit boards **214** of the conventional display apparatus **1**. The flexible printed circuit **218** is bent and attached onto the printed circuit board assembly **216**, wherein attachment units **219** (e.g. tapes) are attached onto the combining section **217**, thereby strengthening the pull strength of flexible printed circuit **218** and reducing the possibility of poor signal transmission induced by the stress acting on the combining section **217**. However, the above combining method needs additional processes for attaching the attachment units **219** to strengthen the combining portion **217**. Furthermore, the ability of the attachment units **219** in strengthening the pull strength of the combining section **217** is limited. For large-size display application, the combining strength of circuit boards **214** should be further improved.

### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a complex circuit board which combines a printed circuit board assembly and a flexible printed circuit.

It is another object of the present invention to provide a complex circuit board to improve the pull strength of a flexible printed circuit.

It is a further object of the present invention to provide a complex circuit board without extra attachment units on the combining sections of circuit boards.

It is yet another object of the invention to provide a display apparatus, including a display panel and a backlight module.

2

A light-emitting device of the backlight module supplies backlight for the display panel. The light-emitting device has light sources and circuit boards. The circuit boards transmit control signals to the light sources to control power and brightness of the light sources. The complex circuit board includes a printed circuit board assembly (PCBA) and a flexible printed circuit (FPC).

The printed circuit board assembly has a supporting section and a connecting section. The supporting section has a supporting surface for supporting the light sources. The connection section extends from the one side of the supporting section and has a first surface extending from the supporting surface, a first side surface adjacent to the first surface, and a first fixing portion disposed on the first side surface. The flexible printed circuit has a contacting section disposed parallel to the connecting section. The contacting section has a first fixing hole and the first fixing portion is inserted into the first fixing hole to couple the flexible printed circuit with the printed circuit board assembly.

Furthermore, the flexible printed circuit has a first bend portion and a second bend portion. The first bend portion and the second bend portion are located on two opposite sides of the contacting section. The flexible printed circuit changes the extending direction at the first bend portion and has an angle with the contacting section, wherein the first fixing hole is located on the first bend portion.

The printed circuit board assembly further has a first connecting unit disposed on the connecting section. The flexible printed circuit has a second connecting unit disposed on the contacting section. The second connecting unit is electrically connected to the first connecting unit to transmit control signals of the light sources.

It is another object of the present invention to provide a fabrication method of a complex circuit board. The method includes forming a first fixing portion on a printed circuit board assembly and a first fixing hole on a flexible printed circuit. The first fixing hole is corresponding to the first fixing unit and the first fixing unit is inserted into the first fixing hole to couple the flexible printed circuit with the printed circuit board assembly to accomplish the fixing process of the circuit boards.

By the above complex circuit board and the fabrication method, the strength of fixing the printed circuit board assembly and the flexible printed circuit is improved to effectively increase the pull strength therebetween. Moreover, without using extra attachment units (e.g. tapes), the assembly procedure is simplified. Consequently, the throughput is increased and the cost is reduced.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of a conventional display apparatus.

FIG. 2A is a schematic view of a conventional light-emitting module.

FIG. 2B is a schematic view showing the assembly of the conventional light-emitting module.

FIG. 3A is a schematic view of the light-emitting module of the present invention.

FIG. 3B is a schematic view showing the structure of the complex circuit board of the present invention.

FIG. 3C is a combined view of the complex circuit board of the present invention.

FIG. 4A is another embodiment of the light-emitting module.

FIG. 4B is another embodiment of the complex circuit board.

3

FIG. 4C is a combined view of another embodiment of the complex circuit board.

FIGS. 5A-5C are embodiments of fixing structures.

FIG. 6 is a flow chart of the fabrication method for the complex circuit board of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention provides a complex circuit board and a fabrication method thereof by using mechanical-combining technique to effectively increase the pull strength of the complex circuit board and strengthen the connection of a printed circuit board assembly and a flexible printed circuit. Furthermore, the elimination of the conventional step of attaching attachment units simplifies the assembly procedure and reduces the cost of attachment units. The complex circuit board of the present invention and a fabrication method thereof can achieve the advantages of improving the strength of the complex circuit board and reducing the product cost.

As shown in FIG. 3A, the complex circuit board includes a printed circuit board assembly 300 and a flexible printed circuit 400. The printed circuit board assembly 300 has a supporting section 310 and a connecting section 320. The supporting section 310 supports several light sources 212. Specifically, the supporting section 310 has a supporting surface 312 and the light sources 212 are disposed on the supporting surface 312. The light sources 212 are preferably light emitting diodes (LEDs) for supplying illumination. The connecting section 320 extends from one end of the supporting section 310 and is provided for fixing and electrically connecting with the flexible printed circuit 400. The flexible printed circuit 400 is preferably formed by cutting from a flexible circuit board and has a contacting section 420. The contacting section 420 of the flexible printed circuit 400 is disposed corresponding to the connecting section 320 of the printed circuit board assembly and electrically connected thereto to transmit control signals of the light sources 212.

FIG. 3B is a partially enlarged view of the complex circuit board. The connecting section 320 of the printed circuit board assembly 300 extends from the end of supporting section 310. The connecting section 320 has a first surface 322 extending from the supporting surface 312 and a first side surface 324 adjacent to the first surface 322. A first fixing portion 325 is disposed on the first side surface 324. In the present embodiment, the first fixing portion 325 is a protrusion on the first side surface 324. The connecting section 320 further includes a second surface 328 corresponding or opposite to the first surface 322, preferably parallel to the first surface 322. The first side surface 324 is situated between the first surface 322 and the second surface 328 and approximately perpendicular to the first surface 322 and the second surface 328. A first connecting unit 327 is disposed on the connecting section 320 and correspondingly adjacent to the first fixing portion 325. In the present embodiment, the first connecting unit 327 is disposed on the second surface 328 and can be, for example, electrical conductive patterns or contact pads to transmit control signals of the light sources 212. The material of the first connecting unit 327 is preferably copper, aluminum or alloys thereof.

The contacting section 420 of the flexible printed circuit 400 has a second connecting unit 427. The contacting section 420 has a third surface 422 and a fourth surface 424 opposite to the third surface 422, wherein the second connecting unit 427 can be disposed on the third surface 422 or the fourth surface 424. In the present embodiment, the second connecting unit 427 is disposed on the third surface 422. The second

4

connecting unit 427 can be electrical conductive patterns or contact pads and the material can be copper, aluminum or alloys thereof. When the third surface 422 of the contacting section 420 and the second surface 328 of the connecting section 320 are correspondingly disposed, the second connecting unit 427 is electrically connected to the first connecting unit 327 of the printed circuit board assembly 300. For example, the second connecting unit 427 can be soldered to the first connecting unit 327 using a hot bar process or electrically connected to the first connecting unit 327 by a thermal press process. A first fixing hole 425 is located between the second connecting unit 427 and the end of flexible printed circuit 400. The first fixing portion 325 is inserted into the first fixing hole 425 to couple the printed circuit board assembly 300 and the flexible printed circuit 400. After the printed circuit board assembly 300 and the flexible printed circuit 400 are combined, the extending directions of the circuit boards 300, 400 are approximately perpendicular to each other.

Referring to FIG. 3C, the first fixing portion 325 is inserted into the first fixing hole 425 to assemble the printed circuit board assembly 300 with the flexible printed circuit 400 and electrically connect the first connecting unit 327 and the second connecting unit 427.

As shown in the FIG. 3B and FIG. 3C, the flexible printed circuit 400 is bent to form a first bend portion 410 and a second bend portion 430. The extending direction of the flexible printed circuit 400 is changed via the first bend portion 410 and the second bend portion 430 from the contacting section 420. The first bend portion 410 and the second bend portion 430 respectively have a bending angle. For example, the bending angle is 90 degrees or other specific degrees modulated according to the product design. In other words, the first bend portion 410 and the second bend portion 430 are located on two opposite sides of the contacting section 420.

Furthermore, as shown in FIG. 3B and FIG. 3C, a first indentation 326 is preferably formed on the connecting section 320 and disposed on at least one side of the first fixing portion 325. In the present embodiment, the first indentations 326 are disposed on two opposite sides of the first fixing portion 325. The first indentation 326 at least partially accommodates the first bend portion 410 of the flexible printed circuit 400. When combining the complex circuit board, the strength of the combining section 330 is improved and the smoothness of the complex circuit board is promoted. Similarly, another indentation can be disposed on the other side surface opposite to the first fixing portion 325 to at least partially accommodate the second bend portion 430 of the flexible printed circuit 400.

By means of the above structural design, the pull strength of the complex circuit board is structurally enhanced without using extra attachment units on the combining portion 330 and the assembly of the complex circuit board is easily accomplished.

As shown in FIG. 4A to FIG. 4C, the present invention provides another embodiment, wherein the elements with same reference numbers are the same as those disclosed in the previous embodiment. As shown in FIG. 4A, the complex circuit board includes a printed circuit board assembly 300 and a flexible printed circuit 400. The printed circuit board assembly 300 has a supporting section 310 and a connecting section 320. The supporting section 310 supports several light sources 212. Specifically, the supporting section 310 has a supporting surface 312 and the light sources 212 are disposed on the supporting surface 312. The light sources 212 preferably include light emitting diodes (LEDs) for supplying illumination. The connecting section 320 extends from one end of the supporting section 310 and is provided for fixing and electrically connecting with the flexible printed circuit 400.

5

The flexible printed circuit **400** is preferably formed by cutting from a flexible circuit board and has a contacting section **420**. The contacting section **420** of the flexible printed circuit **400** is disposed correspondingly to and electrically connected with the connecting section **320** of the printed circuit board assembly **300** to transmit control signals of the light sources **212**.

FIG. 4B is a partially enlarged view of the complex circuit board. The connecting section **320** of the printed circuit board assembly **300** extends from the end of the supporting section **310**. The connecting section **320** has a first surface **322** extending from the supporting surface **312** and a first side surface **324** adjacent to the first surface **322**. A first fixing portion **325** is disposed on the first side surface **324**. In the present embodiment, the first fixing portion **325** is a protrusion on the first side surface **324**. A first connecting unit **327** is disposed on the first surface **322** of the connecting section **320** and adjacent to the first fixing portion **325**. In the present embodiment, the second side surface **329** is parallel to the first side surface **324**. A second fixing portion **321** is disposed on the second side surface **329** and is preferably a protrusion on the second side surface **329**. In the present embodiment, the protrusions of first fixing portion **325** and second fixing portion **321** are symmetrically located on two opposite sides of the first connecting unit **327**. The protrusion of first fixing portion **325** or second fixing portion **321** can be aligned to the first connecting unit **327**, but not limited thereto. That is, the protrusion of first fixing portion **325** or second fixing portion **321** can be not aligned to the first connecting unit **327**. The first connecting unit **327** is electrical conductive patterns or contact pads for transmitting control signals of the light sources **212**. The most common material of the first connecting unit **327** is copper, aluminum or alloys thereof.

The contacting section **420** of the flexible printed circuit **400** has a second connecting unit **427**. The second connecting unit **427** is disposed on the fourth surface **424**. The second connecting unit **427** can be electrical conductive patterns or contact pads and the material is copper, aluminum or alloys thereof. When the fourth surface **424** of the contacting section **420** and the first surface **322** of the connecting section **320** are correspondingly disposed, the second connecting unit **427** is electrically connected to the first connecting unit **327** of the printed circuit board assembly **300**. For example, the second connecting unit **427** can be soldered to the first connecting unit **327** using a hot bar process or electrically connected to the first connecting unit **327** by a thermal press process. The contacting section **420** of the flexible printed circuit **400** further includes a first hook **401** and a second hook **402**. A first fixing hole **425** and a second fixing hole **421** are disposed on the first hook **401** and the second hook **402**, respectively. The first hook **401** and the second hook **402** are bent to form a first bend portion **410** and a second bend portion **430**. The first fixing portion **325** is inserted into the first fixing hole **425** and the second fixing portion **321** is inserted into the second fixing hole **421** to couple and fix the printed circuit board assembly **300** and the flexible printed circuit **400**. After the printed circuit board assembly **300** and the flexible printed circuit **400** are combined, the extending directions (**300a**, **400a**, see FIG. 4B) of the circuit boards **300**, **400** are approximately parallel.

Finally, the flexible printed circuit **400** is bent to form a third bend portion **440**. The extending direction of the flexible printed circuit **400** is changed via the third bend portion **440**. The third bend portion **440** has a bending angle. The bending angle can be a specific degree modulated according to the product design.

6

In the present embodiment, the first bend portion **410** and the second bend portion **430** of the contacting section **420** are symmetrically disposed on two opposite sides of the second connecting unit **427**. The first hook **401** or the second hook **402** can be aligned or not aligned with the second connecting unit **427**.

A first indentation **326** and a second indentation **323** are disposed on one side of the first fixing portion **325** and the second fixing portion **321**, respectively. The first indentation **326** is disposed between the first fixing portion **325** and the supporting section **310**. The second indentation **323** is disposed between the second fixing portion **321** and the supporting section **310**. The first indentation **326** and the second indentation **323** at least partially accommodate the first bend portion **410** and the second bend portion **430** of the flexible printed circuit **400**, respectively. Therefore, the strength of the complex circuit board is improved due to the structural design.

Moreover, as shown in FIG. 5A to FIG. 5C, to enhance the strength of the combining section **330**, the first fixing portion **325** and the second fixing portion **321** can be rectangle, wedge, or arc shaped protrusions, so that the flexible printed circuit **400** and the printed circuit board assembly **300** are prevented from being detached from each other.

The present invention also provides a fabrication method of the complex circuit board. As shown in FIG. 6, the step S10 is forming a first fixing portion **325** on a connecting section **320** of a printed circuit board assembly **300**. In another embodiment, a second fixing portion **321** is further formed on the printed circuit board assembly **300**. The step S10 further includes forming a first indentation **326** and a second indentation **323** on one side of the first fixing portion **325** and the second fixing portion **321**, respectively.

The step S20 includes forming a first fixing hole **425** on a contacting section **420** of the flexible printed circuit **400**. The first fixing hole **425** corresponds to the first fixing portion **325**. In another embodiment, a second fixing hole **421** is formed on the flexible printed circuit **400** and the second fixing hole **421** is disposed corresponding to the second fixing portion **321**.

The step S30 includes inserting the first fixing portion **325** into the first fixing hole **425** and inserting the second fixing portion **321** into the second fixing hole **421** to combine the flexible printed circuit **400** and the printed circuit board assembly **300**.

The step S40 includes bending the flexible printed circuit **400** at the first fixing hole **425** to form the first bend portion **410**. In another embodiment, the first hook **401** with the first fixing hole **425** and the second hook **402** with the second fixing hole **421** are bent to form the first bend portion **410** and the second bend portion **430** of the flexible printed circuit **400**. The first bend portion **410** is parallel to the second bend portion **430**. The first indentation **326** and the second indentation **323** at least partially accommodate the first bend portion **410** and the second bend portion **430** of the flexible printed circuit **400**, respectively.

The step S50 includes bending the flexible printed circuit **400** from another side of the contacting section **420** to form a third bend portion **440**. In another words, before the third bend portion **440** is formed, the bending directions of the first hook **401** and the second hook **402** are respectively perpendicular to the extending direction of the flexible printed circuit **400**.

The step S60 includes electrically connecting the flexible printed circuit **400** and the printed circuit board assembly **300**. The circuit boards **300**, **400** are soldered using the hot bar process. The flexible printed circuit **400** and the printed cir-

7

cuit board assembly **300** are combined and electrically connected via the first connecting unit **427** and the second connecting unit **327**.

Although the preferred embodiments of the present invention have been described herein, the above description is merely illustrative. Further modification of the invention herein disclosed will occur to those skilled in the respective arts and all such modifications are deemed to be within the scope of the invention as defined by the appended claims.

What is claimed is:

**1.** A complex circuit board fabrication method for combining a printed circuit board assembly (PCBA) with a flexible printed circuit (FPC), comprising the steps of:

forming a first fixing portion on a connecting section of said printed circuit board assembly, a first connecting unit being disposed on the connecting section;

forming a first fixing hole on a contacting section of said flexible printed circuit, said first fixing hole corresponding to said first fixing portion, a second connecting unit being disposed on the contacting section;

inserting said first fixing portion of said printed circuit board assembly into said first fixing hole of said flexible printed circuit, and the first connecting unit facing and contacting the second connecting unit;

bending said flexible printed circuit at said first fixing hole to form a first bend portion;

bending said flexible printed circuit from another side of the contacting section to form a second bend portion; and

8

electrically connecting said flexible printed circuit to said printed circuit board assembly by connecting the first connecting unit and the second connecting unit.

**2.** The complex circuit board fabrication method of claim **1**, further comprising a step of forming a second fixing portion on the connecting section of said printed circuit board assembly.

**3.** The complex circuit board fabrication method of claim **2**, further comprising a step of forming a second fixing hole on said flexible printed circuit to correspond to said second fixing portion.

**4.** The complex circuit board fabrication method of claim **3**, further comprising a step of bending said flexible printed circuit at said second fixing hole to form a third bend portion.

**5.** The complex circuit board fabrication method of claim **1**, wherein in said electrically connecting step, said first connecting unit of said printed circuit board assembly is electrically soldered to said second connecting unit of said flexible printed circuit using a hot bar process.

**6.** The complex circuit board fabrication method of claim **1**, wherein the bending directions of said first bend portion and said second bend portion are parallel to the extending direction of said flexible printed circuit.

**7.** The complex circuit board fabrication method of claim **4**, wherein the bending directions of said first bend portion and said third bend portion are substantially perpendicular to the extending direction of said flexible printed circuit.

**8.** The complex circuit board fabrication method of claim **3**, further comprising a step of inserting said second fixing portion into said second fixing hole.

\* \* \* \* \*